DOCUMENT RESUME

ED 291 552 SE 048 877

AUTHOR Licht, Norman
TITLE The Electronic Geoboard: A Method to Assess Science Ability. Revised.
PUB DATE 84
NOTE 14p.; This paper is a revision of one presented at the Conference on Thinking (Cambridge, MA, 1984).
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Computer Assisted Instruction; Computer Uses in Education; *Concept Formation; Courseware; Elementary Education; *Elementary School Science; Geometric Concepts; *Geometric Constructions; *Piagetian Theory; *Problem Solving; Science Education; Scientific Methodology
IDENTIFIERS *Science Education Research

ABSTRACT

The purpose of this study was to determine whether an electronic geoboard, a computer-software program, could be used to assess youngsters' ability to discover facts and relationships in an unlabled and ambiguous situation. Subjects--108 children, ages 6 to 12--were enrolled in grades 1 to 6 in Norwood, New York. The electronic geoboard served as the stimulus material and was used to track the subjects' search behavior. Subjects had to discover a rule that generated a geometric figure onto the points of an array. During the process they left trails of their actions. These were recorded by the computer. The results tended to confirm Piaget's conclusion that science ability is demonstrated by developmentally advanced children. However, the youngsters who solved the rule, and generated a geometric figure, left no discernable pattern in their actions and in the trail that they left. (Author/TW)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED291552

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Norman C Licht

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

X This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

The Electronic Geoboard: A Method to Assess Science Ability *

Norman Licht, Ed.D.
Professor of Education
State University of New York
College of Arts and Sciences
Potsdam, New York 13676 (315) -267-2527

* This paper is a revision of an essay presented at the Conference on Thinking, Harvard University, Cambridge, MA., 1984

SE 048 877

BEST COPY AVAILABLE

Abstract

The purpose of this study was to determine whether an electronic geoboard, a computer-software program, could be used to assess youngsters' ability to discover facts and relationships in an unlabled and ambiguous situation. Subjects included 108 children, who ranged in age from six to twelve years, and who were enrolled in grades 1-6.

The electronic geoboard which served as the stimulus material, was used to track the subjects' search behavior: Subjects had to discover a rule that generated a geometric figure onto the points of an array. During the process they left trails of their actions. These were recorded by the computer.

The results confirmed Piaget's conclusion that science ability is demonstrated by developmentally advanced children. However, the youngsters who solved the rule, and generated a geometric figure, left no discernable pattern in their actions and in the trail that they left. Further research might help explain this phenomenon.

Tests to assess science ability in children from grades one to five are virtually nonexistant. Also, science tests designed to appraise problem-solving skills of children beyond the sixth grade are based almost wholly on science facts and usually exclude questions that involve processes of thinking (Buros, 1978).

The problem might have been that scientific characteristics are difficult to determine, given traditional measures of assessment. Standard testing methods evaluate cognition by means of end-of-process devices rather than by more current instruments used by cognitive scientists. The latter devices are used in attempts to trace thinking from moment-to-moment; that is, by means of recording as trails, the actions taken by youngsters in problem-solving (Bruner et al, 1956; Piaget & Inhelder, 1969).

The aim of this study was to examine a method that was designed to assess the science behavior of youngsters. The methodology included an instrument (the computer and computer program) that would accumulate evidence of the thought process as it occurred. The computer program was derived from an elementary school mathematics enrichment tool called a "geoboard". The program, or computer software, is called an "electronic geoboard" and its activities differ from typical geoboard activities. Originally designed by Donald T. Piele to help computer programmers, the electronic geoboard was used in this study to assess science ability (Piele, 1983). The way it is constructed implies similarities with the way computers are used

to encourage creative problem-solving.

A geoboard is a one-foot square wooden board embedded with a number of nails that project from its surface. After five equally spaced vertical lines and five equally spaced horizontal lines are drawn, nails are hammered at each of the 25 intersection points. (It will look like the image generated by the electronic geoboard in figure 1.).

It is called a geoboard because youngsters may use the device to form different geometric patterns by means of a strong rubber band that they can place around two or more of the nails. Since the instrument has a game-like quality, children will often create a series of geometric patterns without worrying about errors even when the youngsters are observed by adults. The geoboard seems to be an instrument that Piaget might have used in clinically observing youngsters engaged in scientifically oriented behavior. (He had designed unique devices in order to gain insights into a child's scientific capabilities and into the nature of scientific tasks in general.)

Piaget determined that the problem (of discovering which youngsters have scientific capabilities) may be approached by means of externalizing for observation, and recording those characteristics that set science apart from other disciplines (Piaget, 1964). He suggested that the young science-oriented individual is interested in finding an answer to a problem or a puzzling situation; is willing to keep trying in the face of resistance; is inventive and ingenious when suitable equipment is

unavailable; and is patient when one part of an experiment won't work and must be repeated or changed. But most of all, Piaget believed that the child-scientist-to-be is well organized and systematic (Piaget, J. & Inhelder, B., 1969). This last trait may be patently clear, but it bears repeating when describing the factors that are denotive of science-oriented children.

In addition to their behavior of producing regularities in decision-making and their logical approach to problem-solving, young science-oriented individuals have been described as possessing keen powers of observation and an unusual ability to perceive and notice problems: the sort of situations and challanges that may have escaped the attention of others who are less scientifically oriented. And finally, a young scientist is a searcher, who enjoys trying to find new facts, or new ways of doing things. This is because of a greater sensitivity to the unusual, the odd, or the promising aspects of situations, the hidden opportunities often overlooked by less science-oriented individuals (Raudsepp, 1983).

This study was designed to measure and assess a number of those science abilities in children by means of the electronic geoboard. It was indicated earlier that The electronic geoboard is not an ordinary device. Instead, it may be described as a computer program, or software, which is designed to simulate the environment of the non-electronic geoboard. Just as 25 nails appeared on the wooden geoboard, 25 equally spaced points were displayed on a computer screen (figure 1). Also, four separate

rules for generating geometric patterns were built into the software: to create (1) a point, (2) a horizontal line, (3) a vertical line, and (4) a shaded rectangular region defined by a diagonal line between the two chosen points (figures 2-3c).

Statement of the Problem:

The purpose of this study was to determine whether an electronic geoboard could be used to assess science behavior of young children. Science behavior is defined as the ability to discover the facts and relationships in an unlabled and ambiguous situation.

Subjects:

Subjects for this study included 108 children in grades 1-6, from Norwood Elementary School in Norwood, New York; they ranged in age from 6 to 12 years.

Stimulus Materials:

The electronic geoboard has been described as computer software which has been programmed to produce geometric figures by means of an Apple IIe microcomputer. The electronic geoboard was designed to generate 25 equally spaced points in a five by five vertical and horizontal array. No lines would be visible in the array. Only the 25 points of intersection of the lines would appear. In addition, only the numbers 1-5, keys from the first row of the computer keyboard, will produce either a point, a vertical line, a horizontal line or a shaded rectangle region.

One of these figures appears after two sets of numbers have been pressed. In effect, the first number corresponds to a

point in a row in the array, while the second number corresponds to the point in a column. Figure 2 shows the results after the number 5 (row 5) and number 2 (column 2) have been pressed. In Figure 3a, the horizontal line will appear after the numbers 3,1 and 3,5 (or 3,5 and 3,1) are pressed on the keyboard. In figure 3b, the vertical line will appear after the numbers 2,2 and 5,2 are struck. Finally, in figure 3c, a shaded rectangular region will appear after the numbers 3,1 and 5,5 are pressed.

If two identical sets of numbers are pressed, only a single point will appear. If two numbers in the same row but in different columns are picked, then a horizontal line appears. If two numbers in the same column, but in two different rows, are selected, then a verical line will be generated. And if the sets of two numbers are in different rows and columns (two points in a diagonal line), a shaded rectangular region will show on the screen. The entire geoboard area becomes a shaded rectangular region if the selected points are 1,5 and 5,1 (or 5,1 and 1,5).

Figures or points remain on the screen for ten seconds after they have been generated. Then they are removed to make room for new objects. Only the 25 point array remains at all times.

Procedures:

Subjects were seated at microcomputer terminals. After the video screen had displayed the 25 point array, subjects were told:

> "This is a game in which you will press keys on the keyboard and points, lines, or shaded regions will appear on the computer screen. The object of the game is to discover as much as you can about what happens after you press the keys. Only the keys labled 1-5 will work.

> The objects will appear after you have pressed a set of two keys. Then the objects will disappear and you can try another set of numbers. You may press the same or different keys. After five minutes have passed, I will ask you to make one of the shaded regions appear. Try to remember those numbers you have pressed so that you may recall how the objects are formed."

Then the subjects were allowed to select numbers and generate figures for five minutes. At the end of five minutes, the subjects were told:

> "See if you can press the numbers that shade in the whole screen and no points will be seen. You will have two minutes to pick the right numbers."

The session was concluded after the subjects had selected the correct points and reached criterion, or time had elapsed. All of the numbers and geometric figures generated by subjects were saved onto an external memory device-a floppy diskette. These data were available for analysis at the end of the study.

Results and Discussion:

The results were analyzed in terms of the two measures of performance: (a) the number of times that criterion was reached (the entire screen became a shaded rectangle), and (b) the total number of times that subjects selected sets of numbers and generated geometric objects. Table 1 shows the number of subjects who reached criterion. An analysis of the Chi square statistic indicates significance across all grade levels: (X^2 =32.61, df=15, $p < .01$). The data of the total number of geometric objects generated are shown in Table 2. A Chi Square analysis show significant differences: (X^2 =20.82, df=5, $p < .001$). The results indicate a sharp difference between 1-3 and 4-6

It has been demonstrated that upper level elementary school children, in grades 4-6, outperform those in the early grades. These findings are consistant with those offered through the experiments of Piaget in a noncomputer environment (Piaget, 1953). Moreover, when one examines the individual attempts to reach criterion, it is apparent that characteristics such as persistance and search behavior, are more likely to be displayed by the older children. Since these traits are also displayed by science oriented individuals, it would appear that the electronic geoboard might be useful in early identification of such youngsters.

It is not clear whether the older subjects learned from their early trials and were therefore more likely to reach criterion because of the experience. If feedback had been provided, the results might have been consistant with the early work in cognition by Gagne and Brown (1961). Perhaps, conceptual learning might be improved if feedback were more carefully employed. It might benefit science-oriented youngsters if search behavior were encouraged and confirming prompting were reduced. Students who see problems as interesting puzzles may not want to be disturbed in their pursuits.

An effort was made to examine the series of geometric figures that were generated by each subject in order to determine whether systematic selection had occurred. However, there did not seem to be any any consistant pattern to the youngster's actions in the trails that they left.

of the children are consistant with the conclusions that Piaget has drawn—that scientific ability is related to age and development (Piaget and Inhelder, 1969); and secondly, that the computer can simulate experiments that were previously performed manually.

The computer enables one to easily record activities for analysis at a later time without interfering with the experiment. That is, the computer may be used as an electronic experimenter, and derive information that human researchers may not be able to obtain as easily.

The discovery that few students in grades 1-3 were able to generate the numbers that would create a shaded rectangle for the whole geoboard may have confirmed Piaget's conclusions. However, another possibility is that these children were having difficulty with the concept of the diagonal line.

Olson noted that some younger children seem to have problems recognizing and then reconstructing a diagonal (Olson, 1970). This study did not require the subjects to construct a diagonal or even to visualize a diagonal line. However, some understanding of the diagonal may have been necessary in order to generate the shaded rectangular area. It would be a simple matter to modify the electronic geoboard and include a task that involved the diagonal; then, research might help determine why the concept of diagonal lines may be so difficult for some youngsters.

References

Bruner, Jerome S., Goodnow, Jacqueline J., and Austin, George A. (1956). A Study of Thinking. Wiley, New York.

Buros, Oscar K., Ed. (1978). The Eighth Mental Measurement Yearbook Vol.I. Gryphon Press, Highland Park, New Jersey

Gagne, Robert M. and Brown, Larry T. (1961, October). Some Factors in the Programming Of Conceptual Learning. Journal of Experimental Psychology, 62, NO. 4.

Licht, Norman C. (1983). Assessing the Science Abilities of Children by Microcomputer. Paper presented at the Conference on Thinking. Cambridge, MA: Harvard University.

Olson, David R. (1970). Cognitive Development: The Child's Acquisition of Diagonality. Academic Press. New York.

Piaget, Jean and Inhelder, Barbel. (1969). The Early Growth of Logic in the Child. W.W. Norton, New York.

Piele, Donald T. (1983, May). Electronic Geoboard. Creative Computing, Vol. 9, No. 5, pp. 137-144.

Randsepp, Eugene. (1983, August). Profile of the Creative Individual. Creative Computing, p. 170.

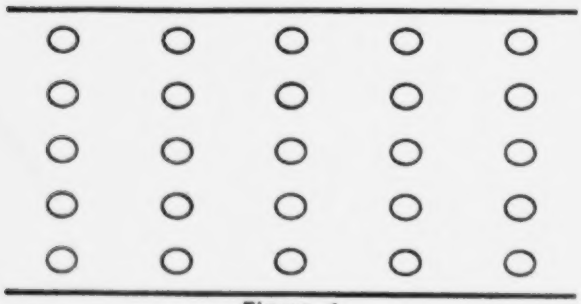

Figure 1

A matrix of 25 equally distributed points as they appeared on the video-screen.

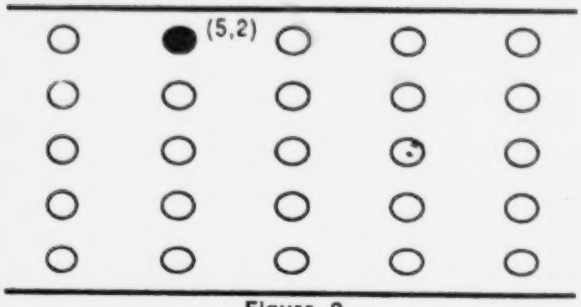

Figure 2

Point 5, 2 (5th row, 2nd column) selected and filled. (Numbers of the rows and columns were not displayed for the Ss).

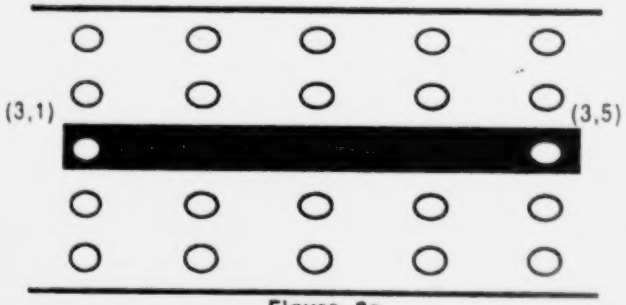

Figure 3a

Points 3,1 and 3,5 selected. They generated the horizontal line which is shaded in. (Numbers were not displayed for Ss).

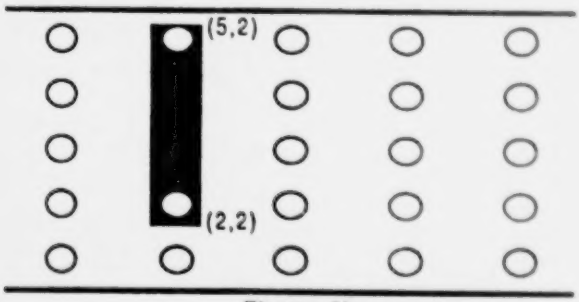

Figure 3b

Points 2,2 and 5,2 selected. They generate the vertical line which is shaded in. (Numbers were not displayed for Ss).

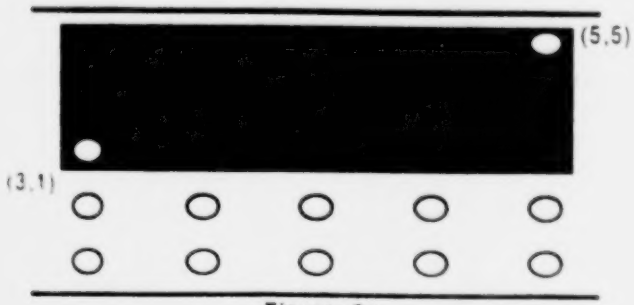

Figure 3c

Points 3,1 and 5,5 selected. They generated the rectangular region which is shaded in. (Numbers were not displayed for Ss).

Table 1

Number of Ss Who Reached Criterion by Grade Level

Grade Level	Reached Criterion	Failed to achieve criterion
1	1	17
2	3	15
3	4	14
4	6	12
5	9	9
6	12	6

Table 2

Total Number of Trials for All Sessions Per Grade Level

Grade Level	Total Number of Trials
1	324
2	317
3	310
4	641
5	942
6	882